**New Program Proposal**
**Doctor of Philosophy in Biomedical Data Science and Informatics**
**Clemson University and the Medical University of South Carolina**
**(Joint Program)**

**Summary**

Clemson University and the Medical University of South Carolina (MUSC) request approval to offer a joint program leading to the Doctor of Philosophy in Biomedical Data Science and Informatics to be implemented in August 2017. The proposed program is to be offered through traditional instruction. The following chart outlines the stages of approval for the proposal; the Advisory Committee on Academic Programs (ACAP) voted to recommend approval of the proposal. The full program proposal and support documents are attached.

| Stages of Consideration | Date | Comments |
|---|---|---|
| Program Proposal Received | 10/3/16 | Not Applicable |
| ACAP Consideration | 11/17/16 | The Clemson representative explained the need for the proposed program to train scientists who can leverage the exponential increase in biomedical data to improve health. The representative then referred to employment projections included in the letter from the external evaluator: the American Medical Informatics Association projected that the U.S. will need an additional 20,000 informatics professionals by 2020. Therefore, the representative reiterated that graduates of the proposed program are urgently needed now.<br><br>The representative also stated that offering this innovative and interdisciplinary program is only possible by leveraging the strengths of Clemson in computing, engineering, public health, and science and of MUSC in biomedical sciences. In response to a question about the potential success of offering a joint program, the Clemson representative stated that the institutions believe the joint program will be successful even though a different program, the USC-MUSC PharmD currently under consideration for separation, was not, because this proposed joint program is designed differently, does not create a new entity (e.g., the South Carolina College of Pharmacy), nor requires the merger of systems and policies.<br><br>Representatives summarized joint-program operations as follows: 1) students will be assigned a home campus but will be required to take courses from both institutions; 2) faculty will remain on their home campuses and build research through common links; and 3) the institutions will operate the program through separate budgets. |

| Stages of Consideration | Date | Comments |
|---|---|---|
| | | Staff appreciated the detail of the Memorandum of Understanding, and inquired about the admissions process it describes and the difference in tuition at the two institutions. The Clemson representative responded that because enrollees will be funded as graduate assistants, they will not pay the tuition rate of either institution.<br><br>ACAP voted to approve the program proposal. |
| Comments and suggestions from CHE staff sent to the institution | 12/6/16 | Staff requested the proposal be revised to:<br>• Provide the date of MUSC President approval;<br>• Include the additional information discussed at ACAP about the nature of the collaboration;<br>• Provide the plan and timeline for developing the new courses;<br>• Explain how the CURI, Zucker Graduate Education Center, and University Center of Greenville sites will be used;<br>• Describe the facilities needed in more detail as well as the plans to provide them;<br>• Identify the funding required for library resources;<br>• Include in the budget justification a statement about when the program is expected to have a net positive cost for MUSC;<br>• Confirm if a cost needs to be provided for program-specific fees, and if so, explain what "Diff+Lab" means;<br>• Identify the Colleges referred to in the Budget Justification regarding the reallocation of funds;<br>• Include the explanation about why this joint program will be successful given the recent separation of the PharmD program as requested at ACAP;<br>• Include program objectives in addition to the student learning objectives; and<br>• Clarify the tuition charged at each institution as discussed at ACAP. |
| Revised Program Proposal Received | 12/12/16 | The revised proposal satisfactorily addressed the requested revisions. |

**Recommendation**

The staff recommends that the Committee on Academic Affairs and Licensing approve the program leading to the Doctor of Philosophy in Biomedical Data Science and Informatics to be implemented in August 2017.

Name of Institution

Medical University of South Carolina and Clemson University propose to jointly implement the proposed degree program

Name of Program (include concentrations, options, and tracks)

**Ph.D., Biomedical Data Science and Informatics**

Program Designation

☐ Associate's Degree
☐ Bachelor's Degree: 4 Year
☐ Bachelor's Degree: 5 Year
☐ Master's Degree
☐ Specialist
☒ Doctoral Degree: Research/Scholarship (e.g., Ph.D. and DMA)
☐ Doctoral Degree: Professional Practice (e.g., Ed.D., D.N.P., J.D., Pharm.D., and M.D.)

Does the program qualify for supplemental Palmetto Fellows and LIFE Scholarship awards?

☐ Yes
☒ No

Proposed Date of Implementation
August 2017

CIP Code: 51.2706

Delivery Site(s)

Medical University of South Carolina
Clemson University (main campus)
Clemson University (CURI campus/ Zucker Family Graduate Education Center)
University Center at Greenville (Clemson University)

Delivery Mode

☒ Traditional/face-to-face*
*select if less than 50% online

☐ Distance Education
☐ 100% online
☐ Blended (more than 50% online)
☐ Other distance education

Program Contact Information (name, title, telephone number, and email address)

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Institutional Approvals and Dates of Approval:

**MUSC**:
Department of Public Health Sciences Curriculum Committee: July 22, 2016
College of Graduate Studies Curriculum Committee: August 26, 2016
Education Advisory Council: September 26, 2016
Deans Council: October 5, 2016
President, October 13, 2016
MUSC Board of Trustees: October 14, 2016

**Clemson**:
School of Computing Graduate Affairs Committee: April 11, 2016
School of Computing Faculty: April 13, 2016
College of Engineering, Computing and Applied Sciences Curriculum Committee: April 22, 2016
University Graduate Curriculum Committee: August 23, 2016
President: September 30, 2016
Board of Trustees: October 15, 2016

## Background Information

State the nature and purpose of the proposed program, including target audience and centrality to institutional mission. (1500 characters)

Biomedical data science and informatics is an interdisciplinary field that applies concepts and methods from computer science and other quantitative disciplines together with principles of information science to solve challenging problems in biology, medicine, and public health. The nation's transition to new healthcare delivery models and the exponential growth in biomedical data translate to a need for professionals with expertise in data science focused in biomedical research who can leverage big data to improve health in the state and the nation. Specialized tracks will initially include precision medicine, population health, and clinical and translational informatics. The program is a unique collaboration for transformation of the health systems of South Carolina that leverages Clemson's strengths in computing, engineering, and public health and MUSC's expertise in biomedical sciences. Our institutions recognize that the combination of our expertise affords synergies that are greater than what either institution offers singly. The existing collaborations between our institutions and among our faculty provide an opportunity to create a unique and valuable program that will benefit our students, our faculty, our institutions, and the state. The proposed program will prepare the next generation of data scientists. It will allow MUSC and Clemson to provide a talent pool for South Carolina and the nation in medical, academic, and industrial enterprises. The target constituency for the program is individuals with undergraduate and graduate computer science, math, engineering, or biomedical sciences backgrounds who wish to make a contribution to biomedical sciences or individual and societal health.

The proposed joint degree program does not propose developing an administrative structure separate from the two participating institutions. As a consequence, it avoids the challenges encountered with the formation of the South Carolina College of Pharmacy which required reconciling faculty-related policies that differed between USC and MUSC. To its credit, the proposed Joint PhD program retains the independence of both institutions and capitalizes on the strengths of both by joining the expertise of the faculty in a common program. Faculty in the program are given adjunct faculty status at the other institution.

List the program objectives. (2000 characters)

The Program Objectives for this Joint degree program are
(1) to produce well trained employees in the biomedical data sciences;
(2) to graduate students in a timely manner;
(3) to deliver a program that graduates would recommend to others;
(4) to meet graduate's expectations about their educational experience in the program.

We will assess these program objectives annually through Enrollment Management records and through surveys conducted with graduates. The data to be reviewed includes, but is not limited to student retention, graduation, and placement of graduates and we will use these data in an annual internal review focused on continuous improvement. See the evaluation and assessment section for further details.

The program design is synergistic in that each institution brings a unique set of skills and expertise; it would not be possible for either institution to offer the program alone. Students in this program will take courses from both institutions to complete the degree, as delineated in the curriculum design section of the proposal. The program is based on integrating core competencies from the fields of biomedical informatics described in the literature [Kulikowski et al 2012, Valenta et al 2016] and data science described by the National Institutes of Health's Big Data to Knowledge (BD2K) initiative [Margolis et al. 2014] and includes the following high level competency areas:

I. Biomedical Informatics foundations and applications:
Understand the fundamentals of biomedical informatics concepts with focus on data science:
- Understand and apply syntactic, semantic, cognitive, social, and pragmatic theories as they are used in biomedical informatics.
- Understand and analyze the types and nature of biomedical data, information, and knowledge.
- Understand and apply a wide array of research design methodologies.
- Comprehend basic ethical and legal principles pertaining to the collection, maintenance, use, and dissemination of data.
- Understand biomedical data representation including data standards and ontologies.
- Understand the principles and fundamentals in the following concentration areas of informatics: precision medicine, population health, and clinical and translational informatics.

II. Computer science, mathematics foundations, statistics, and engineering
Understand theoretical basis and apply technological approaches in the context of biomedical problems. For example:
- Image processing and signal analysis.
- Information documentation, storage, and retrieval.
- Machine learning, including data mining and statistics.
- Networking, security, and databases.
- Natural language processing and semantic technologies.
- Representation of logical and probabilistic knowledge and reasoning.
- Simulation and modeling.
- Software engineering.

III. Population health, health systems, and policy

- Identify the principles and limitations of public health and health care programs.
- Describe a public health problem in terms of magnitude, person, time, and place.
- Design, analyze, and evaluate epidemiologic studies that utilize data science and informatics tools.
- Understand the global, cultural, and social context of health and disease.

IV. Domain biology and medicine

- Understand the foundations of biomedical sciences and the relevance of data science in biomedical applications. This includes but is not limited to the following general areas: biochemistry, molecular biology, pathology, and genomics.

## Assessment of Need

Provide an assessment of the need for the program for the institution, the state, the region, and beyond, if applicable. (1500 characters)

The proposed degree program will help fill a growing need for qualified data scientists with biomedical domain knowledge. The program will provide graduates with marketable skills for informatics careers in biology, medicine, or public health focused on the development of prescriptive analytics from large data sources. These uniquely trained scientists will be critical to existing efforts to improve health outcome rankings in South Carolina. Currently funded initiatives (e.g., NSF South Big Data hub (in which Clemson participates) and the NIH Big Data to Knowledge (BD2K)) will require data scientists, and the proposed program will equip graduates to fill these complex roles.

The immediate and long-term impact of the program is promising. Evidence from external sources (references below from NIH, Health IT Consultant groups, and other institutions) supports that investment in data science (and the provision of precision medicine that such insight affords) translates into increased research funding, innovation, and improved patient outcomes. The economic impact is achieved by creating jobs, expanding research opportunities, and attracting associated entrepreneurial efforts to the state (note that investment in the biomedical informatics market is expected to triple in the next five years). This program may contribute to improving healthcare delivery through precision medicine. For example, because of the discoveries afforded by biomedical informatics, 17,000 strokes could be prevented each year because there is now an available genetic test to properly dose the blood thinner Warfarin; and a 34% reduction in chemotherapy is possible for women with breast cancer if they receive a genetic test of their tumor prior to treatment.

Trainees in the proposed program will be able to provide value to health employers in areas such as precision medicine and provision of best value approaches in population health. Building a stronger presence in data sciences and informatics – in clinical practice, research, and education – is, therefore, a high priority for both institutions. The Ph.D. in Biomedical Data Science and Informatics prepares students to lead research programs in academia, healthcare, public health and industry. The program is unique to South Carolina, and very few programs nationally focus on data science applied to health and biomedical science. The program will provide a new career path for citizens of the state and will help to meet the huge projected demand in the current and future workforce.

- Impact on Research Funding/Entrepreneurialism: https://datascience.nih.gov/bd2k/about
- Impact on healthcare: http://hitconsultant.net/2016/05/09/33609/
- Infographics related to impact: http://hitconsultant.net/2016/09/26/infographic-future-personalized-medicine/
- Experience of peer institutions: http://impact.oregonstate.edu/2015/12/data-science/

**Employment Opportunities**

Is specific employment/workforce data available to support the proposed program?

☒Yes

☐No

| **Occupation** | **Expected Number of Jobs added from 2014-2024** | **Expected N in South Carolina** | **Employment Growth Projection 2014-2024** | **Natl Median pay (2015)** |
|---|---|---|---|---|
| Computer and Information Research Scientists | +2,700 | +20 | 11% | > $100K |
| Computer and Information Systems Managers | +53,700 | +610 | 15% | > $100K |
| Computer Systems Analysts | +118,600 | +1,420 | 21% | $75K-100K |
| Medical Scientists | +9,000 | +20 | 8% | $75K-100K |
| Statisticians | +10,100 | +150 | 34% | $75K-100K |
| Management Analysts | +103,400 | +1,370 | 14% | $75K-$100K |
| Operations research analysts | +27,600 | +270 | 30% | $75K-$100K |
| Biomedical Engineers | +5,100 | +20 | 23% | $75K-$100K |

*Data Sources: National labor values come from Occupational Projections database of the Bureau of Labor Statistics. South Carolina data are provided by the state's Employment Security agency in cooperation with the BLS*.

Provide additional information regarding anticipated employment opportunities for graduates. (1000 characters)

Although many of the occupations tracked by the Bureau of Labor Statistics relate to the responsibilities that graduates with specialized training in Biomedical Data Science and Informatics will assume, the field is a relatively new one, so historic data and even nomenclature for job titles have not yet been fully standardized. The fast-growing opportunities for applying data science and informatics to needs across a broad spectrum of the healthcare ecosystem require new professions in government (federal, regional, and state), health care systems, industry, and academia.

Regional employers experiencing growth in analytics and informatics include MUSC Health, Greenville Health System, AnMed Health, McLeod Health, Palmetto Health, Self Regional Healthcare, Spartanburg Regional Healthcare, PokitDok (https://pokitdok.com), Benefit Focus (https://www.benefitfocus.com/company/careers), and BlueCross BlueShield of South Carolina.

**Note: Only complete this if the Employment Opportunities table and the section that follows the table on page 4 have not previously been completed.**

Will the proposed program impact any existing degree programs and services at the institution (e.g., course offerings or enrollment)?

☐Yes

☒No

## List of Similar Programs in South Carolina

Currently, no comparable PhD program exists in the state of South Carolina.

| Program Name | Institution | Similarities | Differences |
|---|---|---|---|
| PhD, Statistical Genetics & Genetic Epidemiology | University of South Carolina | Some elements of our curriculum are common with this program, specifically those related to our population health track. | While our population health track shares many goals in common with this program, our outlook is broader than statistical analysis and epidemiology, and includes more emphasis on technology, "big data," large-scale computation, and learning healthcare systems. As the USC program has more of a macro-scale outlook, our precision medicine track differs substantially, with focus on improving individual health outcomes, in line with national initiatives (e.g., the recent precision medicine initiative from the White House). Moreover, our emphasis is not just on genetics, but on integrating large-scale multimodal data sources that are increasingly available in healthcare. |
| Bachelors, Data Science Program | College of Charleston | This program focuses on data science at an undergraduate level. | Undergrad vs graduate program. The undergrad degree would serve as an excellent source of qualified applicants for our program. |
| MS, Health Informatics | MUSC | Some elements of our curriculum are common with this program (specifically the classes offered at MUSC). For example, fundamental informatics courses might be shared between the two programs. Both programs seek to produce individuals who can contribute to enhancement of the quality of care in health care delivery settings using informatics. | Biomedical Data Sciences and Informatics graduates will be trained to be the developers of new and innovative tools for precision medicine and population health. The participants in MS Health Informatics program would be qualified to apply the tools developed by PhD graduates into existing electronic health records systems and health care delivery processes. |
| PhD, Biomedical Imaging | MUSC | Certain aspects of this program, such as foundational knowledge of linear algebra and pattern recognition albeit focused on image processing, are in common with this proposal. Some of these courses may be provided as electives. | This program focuses on image acquisition technologies and imaging data analysis methods, whereas the Biomedical Data Science and Informatics PhD focuses on broader applications of informatics and analytics, to a variety of big data problems across a multitude of biomedical and health sciences. |

## Description of the Program

| Projected Enrollment | | | | | | |
|---|---|---|---|---|---|---|
| Year | Fall | | Spring | | Summer | |
| | Headcount | Credit Hours | Headcount | Credit Hours | Headcount | Credit Hours |
| 2017 | 8 | 120 | 8 | 120 | 8 | 80 |
| 2018 | 16 | 240 | 16 | 240 | 16 | 160 |
| 2019 | 24 | 360 | 24 | 360 | 24 | 240 |
| 2020 | 32 | 480 | 32 | 480 | 32 | 320 |
| 2021 | 36 | 540 | 36 | 540 | 36 | 360 |

We expect 3 students per year to enter at MUSC and 5 students per year to enter at Clemson. Students should finish the program in 4-5 years. For purposes of this table, we show 50% completing in 4 years and the remainder completing in 5 years. Students will typically enroll in 12-15 credit hours per semester (10 in summer), though some of these hours will be research and seminar hours in excess of the number required for the degree.

Besides the general institutional admission requirements, are there any separate or additional admission requirements for the proposed program?

☒Yes

☐No

If yes, explain. (1000 characters)

**Admissions criteria:**

**Required:**

- Bachelor's degree in biomedical/health sciences, computing, mathematics, statistics, engineering, or related discipline
- General GRE or hold a US graduate or professional degree in a related area from an accredited program
- One year of calculus; one year of college biology
- Computer programming coursework (e.g. at least one advanced programming course) or substantial experience in industry

**Recommended:**

- Competency in a second related area of the above list (biomedical/health sciences, computing, mathematics, statistics, engineering, or related discipline), as demonstrated by completion of a major, minor or certificate
- Relevant research or work experience
- Coursework in multivariate calculus, linear algebra, probability and statistics, and biostatistics
- One year of computer science coursework that focuses on the fundamentals of computer science and software engineering principles, including abstraction, modularity, and object-oriented programming

Are there any special articulation agreements for the proposed program?

☐Yes

☒No

If yes, identify. (1000 characters)

## Curriculum

**Elements of the degree:** This program is synergistic in that each institution brings a unique set of skills and expertise; it would not be possible for either institution to offer the program alone. Students in this program will take courses from both institutions to complete the degree.

1. Coursework (65-68 hours): Each student will work with the graduate coordinator, academic advisor, and dissertation committee to construct a program of study that conforms to the requirements outlined below and takes into account both the student's prior preparation and intended research area. In cases where the student comes to the program with prior coursework in a required area, the graduate coordinator may approve a substitution. In cases where a student lacks pre-requisites for a required course, the student will be asked to complete both the pre-requisite coursework and the required course. Because the curriculum will be tailored to each student, the time needed to complete the degree will vary, but in general, it is expected that students can complete the degree in five years or less.
    a. Area I – Biomedical foundations and applications (15-16 hours)
    b. Area II – Computing/Math/Stat/Engineering (18 hours)
    c. Area III – Population Health, Health Systems, and Policy (5-6 hours)
    d. Area IV – Domain Biology/Medicine (6-8 hours)
    e. Area V - Lab rotations, seminars, doctoral research (24 hours)
2. Formation of Dissertation Committee
3. Qualifying exam *
4. Dissertation Proposal
5. Defense of research
6. Dissertation

Students who are unable to complete the qualifying exam or choose not to complete all of the requirements for the Ph.D. program will be offered the option to transfer to the related MS program offered by Clemson (proposed in a separate CHE application).

As noted in the table that follows, courses are specific to one institution or the other. Students will not be limited by this structure. Both institutions have technology capable of synchronous learning, whereby students on both campuses can simultaneously 'attend' traditional classes and interact with one another and the instructor in real time. As an example, MUSC students might access Clemson computer science classes in person at the Clemson University Restoration Institute (CURI) in North Charleston or by synchronous connectivity with the Clemson main campus through MUSC's many classrooms fitted with compatible technology. Students can also access lectures and other class materials online asynchronously via the learning management system.

## Curriculum by Category

| | Curriculum by Category* | | | | | |
|---|---|---|---|---|---|---|
| **Area** | **Sub-area** | | **Course number** | **Course name** | | **Credit Hours** |
| Area I – Biomedical informatics foundations and applications | | | | | | **15 - 16** |
| | Research Foundations | | | | Choose 1 course | 3 |
| | | | CLEM:HLTH 8210 | *Health Research I: Design and Measurement (3)* | | |
| | | | CLEM:BIOE 6150 | *Research Principles and Concepts (3)* | | |
| | | | MUSC:HIN-708 | *Applied Statistical and Research Methods (3)* | | |
| | | | MUSC:DHA-866 | *Applied Research (3)* | | |
| | Biomedical Informatics Foundations | | | | 2 required courses | 6 |
| | | | MUSC: (NEW BMI) | *Intro to Biomedical Informatics (3)* | | |
| | | | MUSC: (NEW BMI) | *Biomedical Data standards and ontology (3)* | | |
| | Track-specific core course | | | | Choose 1 course | 3 |
| | | | MUSC: (NEW BMI) | *Precision medicine informatics (3)* | | |
| | | | MUSC: (NEW BMI) | *Population health informatics (3)* | | |
| | | | MUSC: (NEW BMI) | *Clinical and translational informatics (3)* | | |
| | Additional elective | | | | Choose 1-2 courses | 3 (minimum) |
| | | Bioinformatics | | | | |
| | | | CLEM: CPSC 5450 | *Bioinformatics algorithms (3)* | | |
| | | | MUSC: BMTRY 789-02 | *Statistical methods for bioinformatics (2)* | | |
| | | | MUSC: (NEW BMI) | *Panomics (3)* | | |
| | | Consumer and quantified self | | | | |

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|---|---|---|---|---|---|---|
| | | | MUSC: (NEW BMI) | *Consumer and quantified self (2)* | | |
| | | | MUSC: (NEW BMI) | *Health enterprise analytics (2)* | | |
| | **Curriculum by Category*** | | | | | |
| **Area** | **Sub-area** | | **Course number** | **Course name** | | **Credit Hours** |
| Area II – Computing/Math/Stat/Engineering | | | | | | **18** |
| | Mathematical and Computing Foundations | | | | **Choose 1 course** | **3** |
| | | | CLEM:MATH 8050 | *Data Analysis (3)* | | |
| | | | CLEM:STAT 8010 | *Statistical Methods (3)* | | |
| | | | MUSC:BIOMI 810 | *Mathematical Methods in Biomedical Imaging (3)* | | |
| | Data Science | | | | | |
| | | Machine Learning / Data Science | | | **Choose 1 course from this group** | **3** |
| | | | CLEM:CPSC 8100 | *Intro to Artificial Intelligence (3)* | | |
| | | | CLEM:CPSC 6810 | *Data Science (3)* | | |
| | | | MUSC: (NEW BMI) | *Machine Learning (3)* | | |
| | | | | | | |
| | | | | | **Choose 2 courses from remaining groups** | **6 (min)** |
| | | Biostatistics | | | | |
| | | | CLEM:STAT 8190 | *Biostatistics (3)* | | |
| | | | CLEM:HLTH 8310 | *Quantitative Analysis in Health Research I (3)* | | |

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|---|---|---|---|---|---|---|
| | | | MUSC: BMTRY 700 | *Introduction to Clinical Biostatistics (Biostatistics I) (5)* | | |
| | | | MUSC: BMTRY 701 | *Biostatistical Methods II (4)* | | |
| | | Data Mining | | | | |
| | | | CLEM:CPSC 8650 | *Data Mining (3)* | | |
| | | | CLEM:ECE 8560 | *Pattern Recognition(3)* | | |
| | | | CLEM:CPSC 8480 | *Network Science (3)* | | |
| | | | CLEM: MATH 8070 | *Applied Multivariate Statistical Analysis (3)* | | |
| | | | MUSC:BMTRY 719 | *Bayesian Biostatistics (3)* | | |
| | | Visualization and exploratory data analysis | | | | |
| | | | CLEM:CPSC 8040 | *Data Visualization (3)* | | |
| | | | CLEM:CPSC 8810 | *Advanced Visualization (3)* | | |
| | | Image processing | | | | |
| | | | CLEM:ECE 6930 | *Introduction to Computer Vision (3)* | | |
| | | | CLEM:ECE 8770 | *Computer Vision (3)* | | |
| | | | CLEM:ECE | *8470 Digital Image Processing (3)* | | |
| | | | CLEM:BIOE 6310 | *Medical Imaging (3) (&6311 non-credit lab)* | | |
| | | | MUSC:BIOMI 812 | *Signal and Image Processing (3)* | | |
| | | Decision analysis/Knowledge integration / modeling | | | | |
| | | | CLEM:MATH 6410 | *Introduction to Stochastic Models (3)* | | |
| | | | CLEM:ECE 6420 | *Knowledge Engineering (3)* | | |
| | | | CLEM:IE 8030 | *Engineering Optimization and Applications (3)* | | |
| | | | CLEM:IE 8520 | *Prescriptive Analytics (3)* | | |

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|---|---|---|---|---|---|---|
| | | Geospatial analysis | | | | |
| | | | CLEM:PADM 8420 | *GIS for Public Administrators (3)* | | |
| | | | MUSC: (DPHS NEW) | *GIS and Mapping for Public Health (3)* | | |
| | | Algorithms/Data Structures | | | | |
| | | | CLEM:CPSC 8400 | *Design & Analysis of Algorithms (3)* | | |
| | | | CLEM:CPSC 8380 | *Advanced Data Structures (3)* | | |
| | | Natural Language Processing | | | | |
| | | | MUSC: (NEW BMI) | *Biomedical Natural Language Processing (3)* | | |
| | Systems and Data Management | | | | **Choose 2 courses** | **6** |
| | | Data management tools and technology | | | | |
| | | | CLEM:CPSC 6620 | *Database management (3)* | | |
| | | | CLEM:CPSC 8620 | *Database management system design (3)* | | |
| | | | CLEM:CPSC 8470 | *Introduction to information retrieval (3)* | | |
| | | | MUSC:HIN 700 | *Database Management (3)* | | |
| | | Computing environments | | | | |
| | | | CLEM:CPSC 6550 | *Computational Science: Methods & Software Systems (3)* | | |
| | | | CLEM:CPSC/ECE 6780 | *General Purpose Computation on GPUs (3)* | | |
| | | | CLEM : ECE 8780 | *High-Performance Computing with GPUs (3)* | | |
| | | | CLEM:CPSC 8200 | *Parallel Architectures (3)* | | |
| | | | CLEM:ECE 6730 | *Introduction to Parallel Systems (3)* | | |

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|---|---|---|---|---|---|---|
| | | | CLEM:ECE 8750 | *Peer-to-Peer, Wireless, and Cloud Computing (3)* | | |
| | | | CLEM:CH 9300 | *Introduction to Scientific Computing (3)* | | |
| | | Performance and scalability | | | | |
| | | | CLEM:CPSC 8300 | *Systems Modeling (3)* | | |
| | | Human factors / HCI / Usability | | | | |
| | | | CLEM: CPSC 6140 | *Human and Computer Interaction (3)* | | |
| | | | CLEM:HCC 8310 | *Fundamentals of Human-Centered Computing (3)* | | |
| | | | CLEM:IE 6880 | *Human Factors Engineering (3)* | | |
| | | | CLEM:IE 8000 | *Human Factors Engineering (3)* | | |
| | | Applied Software Engineering | | | | |
| | | | CLEM:CPSC 8710 | *Foundations of Software Engineering (3)* | | |

| | **Curriculum by Category*** | | | | | |
|---|---|---|---|---|---|---|
| **Area** | **Sub-area** | | **Course number** | **Course name** | | **Credit Hours** |
| Area III – Population Health, Health Systems, and Policy | | | | | Choose 2 courses with different titles | **5-6** |
| | Health Systems | | | | | |
| | | | CLEM:HLTH 8110 | *Health Care Delivery Systems (3)* | | |
| | | | CLEM:HLTH 8020 | *Health Economics (3)* | | |
| | | | CLEM: HLTH 8140 | *Health System Quality Improvement (2)* | | |

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|---|---|---|---|---|---|---|
| | Health Policy | | | | | |
| | | | CLEM:HLTH 8100 | *Health Policy (3)* | | |
| | | | MUSC:HAP 704 | *Health Policy (3)* | | |
| | Quality & Safety | | | | | |
| | | | CLEM:HLTH 8140 | *Health System Quality Improvement (2)* | | |
| | | | MUSC:HAP 632 (3) | *Quality Management of Health Care Services (3)* | | |
| | Ethical, Legal & Social Issues, Privacy and Security | | | | | |
| | | | MUSC:HAP 735 | *Health Law and Risk Management (3)* | | |
| | | | MUSC: HIN 716 | *Ethical, Legal and Regulatory Issues in Health Informatics (3)* | | |
| | Population Health | | | | | |
| | | | CLEM:HLTH 8130 | *Population Health and Research (2)* | | |
| | | | CLEM:HLTH 8900 | *Epidemiology (3)* | | |
| | | | MUSC:BMTRY 736 | *Foundations of Epidemiology I (3)* | | |
| | | | MUSC:BMTRY 747 | *Foundations of Epidemiology II (3)* | | |

| | **Curriculum by Category*** | | | | | |
|---|---|---|---|---|---|---|
| **Area** | **Sub-area** | | **Course number** | **Course name** | | **Credit Hours** |
| Area IV– Domain Biology/Medicine | | | | | Choose 1 course | 3 -4 |
| | Foundations of Biomedical Sciences | | | | | |
| | | | CLEM:BIOE 8460 | *Biomedical Basis for Engineered Replacement (3)* | | |
| | | | MUSC:CGS-765 | *Proteins: Dynamic Structure and Functions (3)* | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | MUSC:CGS-766 | *Genes: Inheritance and Expression (4)* | | |
| | | | MUSC:CGS-767 | *Cells: Organization and Communication (3)* | | |
| | Biochemistry / Pathology | | | | | |
| | | | CLEM:BCHM 6360 | *Molecular Biology: Genes to Proteins (3)* | | |
| | | | CLEM:BHCM 6430 | *Molecular Basis of Disease (3)* | | |
| | Genetics | | | | | |
| | | | CLEM:GEN 6700 | *Human Genetics (3)* | | |
| | Genomics | | | | | |
| | | | CLEM:BIOL 6030 | *Introduction to Applied Genomics (3)* | | |
| **Curriculum by Category*** | | | | | | |
| **Area** | **Sub-area** | | **Course number** | **Course name** | | **Credit Hours** |
| Area V– Lab rotations, seminars, doctoral research | | | | | | 24+ |
| | Lab rotations (MUSC:CGS-720/721) | | | Students engage in lab rotations during the first 2 semesters<br>(4 hours max credit toward degree; additional hours as desired for experience) | | 4 (max) |
| | Seminars (MUSC: NEW BMI) | | | Students should attend two seminars every semester (on a credit or non-credit basis)<br>All students should attend the Biomedical Data Science & Informatics seminar every semester<br>Students should select an additional seminar series related to their research interest<br>(4 hours max credit toward degree; additional hours as desired) | | 4 (max) |
| | Doctoral research hours | | | Once a topic has been selected, students should register for doctoral research hours. A minimum of 18 hours is required for the degree. Students may continue to enroll in doctoral research to reflect the effort of student and advisor while the student is engaged in dissertation research. | | 18 |

| | | | | | | |
|---|---|---|---|---|---|---|

## Course Descriptions for New Courses

Clemson's courses are approved and developed. At MUSC, the new courses to be offered in the Fall of the first year of the program (Intro to Biomedical Informatics; Biomedical Data Standards and Ontology) will be developed by the Biomedical Informatics Curriculum Committee, which meets monthly. The plan is to have these courses approved by the College of Graduate Studies (CGS) Curriculum Committee in April 2017 and will be ready for enrollment by August 2017. Courses to be offered in the Spring semester of 2018 (Precision Medicine Informatics; Population Health Informatics; Clinical and Translational Informatics; and Panomics) will be similarly developed and approved by the CGS Curriculum Committee in October 2017; courses to be offered in year two of the program (Fall 2018) (Consumer and Quantified Self; Biomedical Natural Language Processing; Health Enterprise Analytics; Machine Learning; and GIS and Mapping for Public Health) will be approved in Spring of 2018 and will be ready for enrollment by Fall 2018.

| Course Name | Description |
|---|---|
| Intro to Biomedical Informatics (3) (MUSC) | This course provides an introduction to the fundamental principles of biomedical informatics. Students will examine the unique characteristics of biomedical data and methods for representation of data, information, and knowledge to further the science and improve health. The course provides an introduction to data standards, information security and confidentiality, and methods underlying many biomedical informatics applications, including information retrieval, medical decision making, evaluation of evidence and knowledge representation. |
| Biomedical Data standards and ontology (3) (MUSC) | This course will explore the concepts of interoperability across a variety of biomedical information systems and tools. Students will examine several categories of data standards including controlled vocabularies, standard data models and ontologies. Students will learn value of a standards-based approach to integration. Standards critical for healthcare interoperability and research systems will be examined in greater depth. Examples include but are not limited to HL7 RIM, ICD, LOINC, and SNOMED. Use cases will be examined for the utilization of these standards in various national and industry-wide efforts. Students will gain experience in navigating through standards repositories, documents, and tools. |
| Precision medicine informatics (3) (MUSC) | This course will focus on the inherent translational informatics challenges, concerns, and opportunities afforded by precision medicine to provide a more accurate, personalized characterization of patient populations based on various characteristics including molecular (e.g., genomic, proteomic), clinical (e.g., comorbidities), environmental exposures, lifestyle, patient preferences, and other information. Informatics is a necessary component to tackle precision medicine. This includes managing big data, creating learning systems for knowledge generation, providing access for individual involvement, and ultimately supporting the optimal delivery of precision treatments derived from translational research. |
| Population health informatics (3) (MUSC) | This course will introduce students to the principles of and methods underlying assessment of the health of and management of populations using informatics and data sciences. The scope of the course will span from traditional public health to healthcare applications. Specific topics covered will include syndromic surveillance, outbreak simulation and modeling, population health assessment, healthcare quality measurement, health status and functional outcome measurement, patient reported outcome and quality of life measurement, risk stratification and severity of illness modeling, similarity measurement, time series analysis, statistical process control including open and closed loop control techniques, discrete event simulation, traditional and Bayesian mixed effects non-linear models, and expert-system methods. |

| | |
|---|---|
| Clinical and translational informatics (3) (MUSC) | This course will introduce the student to the principles of clinical and translational research informatics. Topics include the design of clinical research, clinical trial administration, good clinical data management, research participant recruitment, use of administrative databases, registries and electronic health records in research, standards in terminology and messaging for clinical research, and research collaboration. Students will also be familiarized with existing systems, tools, and national efforts in the translational research community (such as i2b2, REDCap, and PCORnet) along with cutting edge research in this area. |
| Panomics (3) (MUSC) | This course will introduce the students to the analysis of 'omics' data, i.e. data obtained from high-throughput platforms. Issues related to integrating information from multiple heterogeneous sources will be the main focus of the course. The students will read seminal papers describing exemplary analyses within 'omics' domains, such as gene expression, gwas, transcriptomics, microbiomics/metagenomics, proteomics, metabolomics, etc. They will next obtain the raw or intermediate datasets from these papers and attempt to reproduce elements of the analyses, which are feasible within the timeframe of the course. Next papers reporting multiple 'omics' datasets will be used to develop the understanding of panomic analyses. Finally, the students will propose and execute analyses of these existing data that go beyond what is published. This course will prepare the students to analyze data and understand key issues with datasets from multiple sources and how to analyze several high-dimensional datasets simultaneously. |
| Consumer and quantified self (2) (MUSC) | Consumer Health Informatics (CHI) is the branch of health informatics that analyzes consumer's needs for health information; studies and implements methods and tools for making information accessible to consumers; and models and integrates consumers' preferences into medical information systems. With the increasing emphasis on patient-centered care and demand of self-care by patients, CHI has become a critical part of the national movement to improve healthcare and reduce costs. This course will discuss the requirements of CHI tools, state of art applications, and challenges and opportunities in CHI research and development. |
| Biomedical Natural Language Processing (3) (MUSC) | In this course the students will examine current natural language processing (NLP) methods and their applications in the biomedical domain. The course will provide a systematic introduction to basic knowledge and methods used in NLP research as well as hands-on experience with existing biomedical NLP systems. Students will gain knowledge and skills in various NLP tasks such as information extraction, information retrieval, named entity recognition, classification tasks and concept mapping. |
| Health enterprise analytics (2) (MUSC) | In this course the students will learn the elements of business intelligence and business analytics pertinent to healthcare enterprise. The students will gain understanding of the business side of hospital operations, the data that are being generated by daily hospital operations and how to use these data to improve processes, outcome, and bottom line. |
| Machine Learning (3) (MUSC) | Machine learning is growing in popularity among biomedical investigators due to the pressing need to systematize and extract the knowledge from multivariate datasets encountered in research application. This course will introduce key concepts in machine learning, descriptive unsupervised analysis, and supervised learning. Several popular machine learning frameworks, such as Support Vector Machines (SVMs), Random Forests, Neural Networks will be presented. Weka and RWeka will be introduced and applied to reanalysis of several biomedical datasets. Basic knowledge of R is highly encouraged. |
| GIS and Mapping for Public Health (3) (MUSC) | In this course students will learn practical Geographic information systems (GIS) skills that can be applied in any public health setting. There are two goals for this course: 1) for students to develop a GIS toolkit by learning the most frequently used GIS skills; and 2) for students to learn how to apply GIS in public health setting through the exploration of applicability of GIS to public health data. The course will involve hands-on training in GIS methods and tools. |

## Faculty

| Faculty and Administrative Personnel (MUSC) – *biomedical informatics* | | | | |
|---|---|---|---|---|
| **Rank** | **Full- or Part-time** | **Courses Taught or To be Taught, Including Term, Course Number & Title, Credit Hours** | **Academic Degrees and Coursework Relevant to Courses Taught, Including Institution and Major** | **Other Qualifications and Comments (i.e., explain role and/or changes in assignment)** |
| Associate Professor 1 (supervisor) | Full time | Clinical and translational informatics (3) | MD American Univ of Beirut. Fellowship (Informatics) Harvard/MIT | |
| Professor 1 | Full time | Population health informatics (3) | MD Univ of California, Los Angeles, MSc (medical informatics) Stanford Univ | |
| Professor 2 | Full time | Database Management MUSC:HIN 700 (3), Applied Statistical and Research Methods MUSC:HIN-708 (3) | PhD (Computer Science) Flinders Univ of South Australia | |
| Professor 3 | Full time | Bayesian Biostatistics MUSC:BMTRY 719 (3) | PhD (Statistics) Univ of St Andrews, UK | |
| Associate Professor 2 | Full time | Machine Learning (3), Panomics (3) | PhD (Biomathematics) Univ of California, Los Angeles | |
| Associate Professor 3 | Full time | Precision medicine informatics (3) | PhD (Computer Science), Fellow (Biomedical Informatics) Vanderbilt Univ | |
| Associate Professor 4* | Full time | Biomedical Data standards and ontology (3) | PhD or MD (Biomedical Informatics) | |
| Assistant Professor 1 | Full time | Intro to Biomedical Informatics (3), | PhD (Biomedical Informatics) Univ of Utah | |
| Assistant Professor 2 | Full time | Biomedical Natural Language Processing (3) | MD North Sichuan Medical School, China, MS (Computer Science) Purdue Univ | |
| Assistant Professor 3 | Full time | Statistical methods for bioinformatics (2) | PhD (Statistics) Univ of Wisconsin, Madison | |

| Faculty and Administrative Personnel (Clemson) – *computer science* | | | | |
|---|---|---|---|---|
| **Rank** | **Full- or Part-time** | **Courses Taught or To be Taught, Including Term, Course Number & Title, Credit Hours** | **Academic Degrees and Coursework Relevant to Courses Taught, Including Institution and Major** | **Other Qualifications and Comments (i.e., explain role and/or changes in assignment)** |
| Professor 1 (Supervisor) | Full-time | CPSC 8470-Introduction to Information Retrieval (3) | PhD Computer Science, Georgia Institute of Technology | |
| Professor 2 | Full-time | CPSC 8200-Parallel Architecture (3) | PhD Computer Science, Vanderbilt University | |
| Professor 3 | Full-time | CPSC 8620-Database Management System Design (3), CPSC 6620-Database Management Systems (3), CPSC 8650-Data Mining (3) | PhD Computer Science, University of Central Florida | |
| Professor 4 | Full-time | CPSC 6780-General Purpose Computation on Graphical Processing Units (3) | PhD Mathematics, University of Notre Dame | |
| Professor 5 | Full-time | CPSC 8040-Data Visualization (3) | PhD Visual Computing , UMass Amherst | |
| Professor of Practice 1 | Full-time | CPSC 6810-Selected Topics in Data Science (3) | PhD Political Science, New York University | |
| Professor Emeritus 1 | Part-time | CPSC 8380-Advanced Data Structures (3) | PhD Communication Sciences, University of Michigan | |
| Professor Emeritus 2 | Part-time | CPSC 6550-Computational Science (3) | PhD Mathematical Sciences, Clemson University | |
| Associate Professor 1 | Full-time | CPSC 8450-Bioinformatics Algorithms (3), CPSC 8400-Design & Analysis of Algorithms (3), | PhD Computer Science, MIT | |
| Associate Professor 2 | Full-time | CPSC 6140-Human and Computer Interaction (3) | PhD Engineering Psychology, Georgia Institute of Technology | |
| Associate Professor 3 | Full-time | CPSC 8100-Introduction to Artificial Intelligence (3) | PhD Computer Science, University of Texas at Dallas | |
| Associate Professor 4 | Full-time | CPSC 8300-Systems Modeling (3) | PhD Electrical Engineering, North Carolina State University | |
| Associate Professor 5 | Full-time | CPSC 8710-Foundations of Software Engineering (3) | PhD Computer Science, Vanderbilt University | |

Note: Individuals should be listed with program supervisor positions listed first. Identify any new faculty with an asterisk next to their rank

| **Faculty and Administrative Personnel (Clemson) – *computer science, engineering & mathematics*** | | | | |
|---|---|---|---|---|
| **Rank** | **Full- or Part-time** | **Courses Taught or To be Taught, Including Term, Course Number & Title, Credit Hours** | **Academic Degrees and Coursework Relevant to Courses Taught, Including Institution and Major** | **Other Qualifications and Comments (i.e., explain role and/or changes in assignment)** |
| Assistant Professor 1 | Full-time | CPSC 8480-Network Science (3), CPSC 8490-Principles of Scientific Computing (3), CPSC 8810-Advanced Visualization (3) | PhD, Weizmann Institute of Science, Israel | |
| Assistant Professor 2 | Full-time | HCC 8310-Fundamentals of Human-Centered Computing (3) | PhD Informatics, University of California | |
| Professor 1 | Full-time | IE 8520-Prescriptive Analytics (3), IE 6880 – Human Factors Engineering (3) | PhD Industrial & Systems Engineering, Virginia Tech | |
| Professor 2 | Full-time | BIOE 6150-Research Principles and Concepts (1) | PhD Biomedical Engineering, University of Montreal, Quebec | |
| Professor 3 | Full-time | MATH 6410-Introduction to Stochastic Models (3) | PhD Mathematics, Carnegie-Mellon University | |
| Professor 4 | Full-time | STAT 8010-Statistical Methods I (3) | PhD, Clemson University | |
| Professor 5 | Full-time | MATH 8050-Data Analysis (3)<br>MATH 8070-Applied Multivariate Analysis (3) | PhD Biometry, Medical University of South Carolina | |
| Associate Professor 1 | Full-time | BCHM 6360-Molecular Biology: Genes to Proteins (3) | PhD Biochemistry, Louisiana State University | |
| Associate Professor 2 | Full-time | ECE 6730-Introduction to Parallel Systems (3) | PhD Computer Science, Georgia Tech | |
| Associate Professor 3 | Full-time | IE 8030-Engineering Optimization & Application (3) | PhD Industrial & Systems Engineering, University of Florida | |
| Assistant Professor 1 | Full-time | IE 8000-Human Factors Engineering (3) | PhD Industrial Engineering, University of Iowa | |
| Assistant Professor 2 | Full-time | BIOE 6310-Medical Imaging (2)<br>BIOE 6311-Medical Imaging Lab 2) | PhD Biomedical Engineering, Vanderbilt University | |
| Adjunct Professor 1 | Part-time | ECE 8770-Computer Vision (3)<br>ECE 8470-Digital Image Processing (3) | PhD Electrical Engineering, Stanford University | |

Note: Individuals should be listed with program supervisor positions listed first. Identify any new faculty with an asterisk next to their rank

| Faculty and Administrative Personnel (Clemson) – *public health sciences* | | | | |
|---|---|---|---|---|
| **Rank** | **Full- or Part-time** | **Courses Taught or To be Taught, Including Term, Course Number & Title, Credit Hours** | **Academic Degrees and Coursework Relevant to Courses Taught, Including Institution and Major** | **Other Qualifications and Comments (i.e., explain role and/or changes in assignment)** |
| Professor 1 | Full-time | HLTH 8140-Health System Quality Improvement (2) | PhD, Health Policy; Brandeis University | |
| Professor 2 | Full-time | HLTH 8130-Population Health & Research (2) | PhD, Public Health Education and Promotion, University of South Carolina, Arnold School of Public Health | |
| Associate Professor 1 | Full-time | HLTH 8110-Health Care Delivery Systems (3) | PhD Public Administration & Policy, SUNY Albany | |
| Associate Professor 2 | Full-time | HLTH 8090-Epidemiological Research (3) | PhD, Nutritional Epidemiology; John Hopkins University<br>MD, Jiao Tong University School of Medicine | |
| Associate Professor 3 | Full-time | HLTH 8020-Health Economics (3);<br>HLTH 8100-Health Policy (3) | PhD, Policy Analysis; Pardee RAND Graduate School | |
| Assistant Professor 1 | Full-time | HLTH 8310-Quantitative Analysis in Health Research I (3) | PhD, Policy Analysis; Pardee RAND Graduate School | |
| Assistant Professor 2 | Full-time | HLTH 8210-Health Research I: Design & Measurement (3) | PhD, International Health; Harvard University School of Public Health | |

Note: Individuals should be listed with program supervisor positions listed first. Identify any new faculty with an asterisk next to their rank

Total FTE needed to support the proposed program (i.e., the total FTE devoted just to the new program for all faculty, staff, and program administrators):

| | | | | | |
|---|---|---|---|---|---|
| **MUSC:** | | | | | |
| Faculty | 1.0/FTE yr | Staff | 0.3/FTE yr | Administration | 0.10/FTE yr |
| **Clemson:** | | | | | |
| Faculty | 1.0/FTE yr | Staff | 0.3/FTE yr | Administration | 0.10/FTE yr |

## Faculty /Administrative Personnel Changes

Provide a brief explanation of any additional institutional changes in faculty and/or administrative assignment that may result from implementing the proposed program. (1000 characters)

**MUSC**: Ten faculty at 0.10 FTE to teach courses, 0.30 FTE for Staff support and a 0.10 for faculty member to serve as program co-director at MUSC.

**CLEMSON:** One new faculty member (0.75 FTE) to support teaching of new courses in machine learning and data science, 0.30 FTE for staff support and 0.10 for faculty member to serve as program co-director at Clemson.

## Library and Learning Resources

Identify current library/learning collections, resources, and services necessary to support the proposed program and any additional library resources needed. (1000 characters)

**MUSC**: Current MUSC library resources are adequate to support the proposed program. The library is a database and knowledge center, academic computing support unit, electronic education center, and leader in information planning. Online resources include the full catalog as well as major biomedical and health-related databases. The library employs over 20 staff, including more than 10 librarians, and each college at MUSC has a specific librarian assigned to serve its students.

**CLEMSON**: The Clemson University Library holdings and electronic access are adequate to support the program. All major journals in our files are available online or through open access. No additional library resources are anticipated. The libraries hold more than 1.8 million items including books, periodicals, electronic resources, digital media collections, government publications and patents, musical recordings, maps and microforms. The required resources for the proposed program are available through Interlibrary Loan and PASCAL which are available to students and faculty without cost as they are covered by the R.M. Cooper Library existing budget. In addition, places to study and meet are available for student teams as needed in addition to technology items (e.g., photography, video, projectors, etc).

## Student Support Services

Identify academic support services needed for the proposed program and any additional estimated costs associated with these services. (500 characters)

Students will have a “home institution” which will maintain accurate records for enrollment and other services. The student’s home institution will be responsible for providing appropriate student support services. Both institutions have sufficient student services to support graduate students. The MOU between the institutions details support services access including funding and access for students who are enrolled in courses at their non-home institution.

## Physical Resources

Identify any new instructional equipment needed for the proposed program. (500 characters)

**MUSC:** It is not anticipated that additional equipment will be necessary. The current computing and data storage equipment will be updated and replaced using the normal acquisition process.

**Clemson:** We anticipate the need for space and student workstations for up to 10 students (year 1 & 2 students). We anticipate that students in years 3+ will reside in the labs and offices associated with their thesis advisors. Current IT and network support will be sufficient to accommodate students. The Office of the Provost at Clemson will allocate approximately 1000 sq.ft. of office and laboratory space to support program faculty, students, post-doctoral fellows, and staff. This space includes 120 sq.ft. for a staff administrative coordinator, 150 sq.ft. for a program office, and 50-60 sq.ft. for each doctoral student in year 1 or 2 of the program. This would mean 250-300 sq.ft. in year 1 and 500 – 600 sq. ft. in year 2 and onward.

Will any extraordinary physical facilities be needed to support the proposed program?

☐Yes

☒No

Identify the physical facilities needed to support the program and the institution’s plan for meeting the requirements, including new facilities or modifications to existing facilities. (1000 characters)

**MUSC**: Given that anticipated annual enrollment in this program is relatively small, the current physical plant will be adequate to meet the educational needs of the students. The core classes taught to students will be conducted in existing classrooms in Cannon Place, the Bioengineering building, and the Drug Discovery building as needed. These classrooms are all equipped with SmartBoard technology, high definition cameras, high-fidelity projection systems, and all necessary audiovisual equipment.

**Clemson:** Classroom facilities for high-definition video telepresence currently exist at the Clemson main campus, the Zucker Graduate Education Center in North Charleston (CURI), the University Center at Greenville and at MUSC. Through these facilities, it will be possible for students to participate in classes from any of these sites. Students will interact not only with the professor at a remote site, but will see, hear and interact with students at other locations, all in real time.

| Estimated New Costs by Year MUSC | | | | | | |
|---|---|---|---|---|---|---|
| **Category** | **1st** | **2nd** | **3rd** | **4th** | **5th** | **Total** |
| Program Administration | 17,493 | 18,017 | 18,558 | 19,115 | 19,688 | 92,872 |
| Faculty Salaries | 159,869 | 164,665 | 169,605 | 174,693 | 179,933 | 848,765 |
| Tuition | 13,770 | 28,366 | 43,826 | 60,187 | 77,491 | 223,641 |
| Annual Fees | 375 | 788 | 1,240 | 1,736 | 2,279 | 6,418 |
| Fees - 1st Year | 1,485 | 1,559 | 1,637 | 1,719 | 1,805 | 8,206 |
| Stipends | 82,500 | 165,000 | 247,500 | 330,000 | 412,500 | 1,237,500 |
| Fringe | 7,095 | 14,190 | 21,285 | 28,380 | 35,475 | 106,425 |
| Health Insurance | 6,690 | 13,380 | 20,070 | 26,760 | 33,450 | 100,350 |
| Equipment | 6,000 | 3,000 | 3,000 | 3,000 | 3,000 | 18,000 |
| Facilities | - | - | - | - | - | - |
| Supplies and Materials | 750 | 773 | 796 | 820 | 844 | 3,982 |
| Library Resources | - | - | - | - | - | - |
| Other* | 13,875 | 9,203 | 9,479 | 9,764 | 10,056 | 52,377 |
| **Total** | **309,902** | **418,941** | **536,996** | **656,174** | **776,522** | **2,698,536** |
| **Sources of Financing** | | | | | | |
| **Category** | **1st** | **2nd** | **3rd** | **4th** | **5th** | **Total** |
| Grant Funded Tuition | - | 14,183 | 29,217 | 45,141 | 61,993 | 150,534 |
| Grant Funded Stipends | - | 82,500 | 165,000 | 247,500 | 330,000 | 825,000 |
| Grant Funded Fees | - | 375 | 788 | 1,240 | 1,736 | 4,139 |
| CGS Dean's Tuition | 13,770 | 14,183 | 14,609 | 15,047 | 15,498 | 72,804 |
| CGS Dean's Stipend, Fringe & Health Insurance | 91,825 | 181,555 | 268,785 | 360,889 | 450,559 | 1,353,613 |
| CGS Dean's Fees (includes 1st year fee) | 1,860 | 1,953 | 2,051 | 2,153 | 2,261 | 10,278 |
| State Funding (i.e., Special State Appropriation)* | - | - | - | - | - | - |
| Reallocation of Existing Funds* | - | - | - | - | - | - |
| Federal Funding* | - | - | - | - | - | - |
| Other Funding* | - | - | - | - | - | - |
| **Total** | **107,455** | **294,749** | **480,449** | **671,970** | **862,048** | **2,416,368** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Net Total (i.e., Estimated New Costs)** | **(202,447)** | **(124,191)** | **(56,547)** | **15,796** | **85,526** | **(282,167)** |

| **Estimated New Costs by Year CLEMSON** | | | | | | |
|---|---|---|---|---|---|---|
| **Category** | **1st** | **2nd** | **3rd** | **4th** | **5th** | **Total** |
| Program Administration | | | | | | - |
| Faculty & Staff Salaries | 216,597 | 210,243 | 213,991 | 175,380 | 179,793 | 996,004 |
| Graduate Assistants | 149,001 | 304,430 | 466,511 | 635,470 | 649,236 | 2,204,648 |
| Equipment | | | | | | - |
| Facilities | 210 | 428 | 655 | 891 | 909 | 3,095 |
| Supplies & Materials | 67,575 | 45,888 | 51,891 | 57,922 | 59,629 | 282,905 |
| Library Resources | | | | | | - |
| Other Admin Cost | 44,615 | 19,129 | 28,758 | 70,340 | 90,071 | 252,913 |
| **Total** | **477,997** | **580,119** | **761,806** | **940,004** | **979,638** | **3,739,564** |
| **Sources of Financing** | | | | | | |
| **Category** | **1st** | **2nd** | **3rd** | **4th** | **5th** | **Total** |
| Tuition Funding | 9,960 | 19,920 | 29,880 | 39,840 | 39,840 | 139,440 |
| State Funding (i.e., Special State Appropriation) | | | | | | - |
| Reallocation of Existing Funds | 150,000 | 300,000 | 350,000 | 450,000 | 450,000 | 1,700,000 |
| Federal Funding | | | | | | - |
| Other Funding | - | 165,521 | 473,018 | 647,006 | 663,749 | 1,949,294 |
| **Total** | **159,960** | **485,441** | **852,898** | **1,136,846** | **1,153,589** | **3,788,734** |
| **Net Total (i.e., Estimated New Costs)** | **(318,037)** | **(94,677)** | **91,092** | **196,842** | **173,951** | **49,170** |

## Budget Justification

Provide a brief explanation for the other new costs and any special sources of financing (state funding, reallocation of existing funds, federal funding, or other funding) identified in the Financial Support table. (1000 characters)

**Note: Institutions need to complete this budget justification *only* if any other new costs, state funding, reallocation of existing funds, federal funding, or other funding are included in the Financial Support table.**

### Tuition

The tuition at MUSC for the Joint PhD in FY18 is $1,566 per semester for Fall and Spring, and $1,458 for the Summer semester. Therefore, the total for the first year of the program is $4,715 (includes tuition for three semesters plus an annual fee of $125). Clemson's graduate tuition per semester is currently $4413/resident and $9,212 non-resident (if on an assistantship, a graduate student pays $974/semester). It is important to note that all doctoral students in the program, regardless of their home institution, will not perceive the difference in tuition at Clemson and MUSC because in all cases, students' tuition and fees will be covered by tuition waivers and funded research grants.

### MUSC

At MUSC there will be no reallocation of funds to offset the negative balance. This balance consists primarily of faculty salaries and is part of the operating cost of the Biomedical Informatics Center, which is supported by MUSC at the highest levels as a strategic initiative. While the program may not provide immediate financial return, it is believed to have long term pay off by providing access to graduate students to support research projects, by advancing our standing in data science and precision medicine, as well as creating future opportunities for grants and collaborations with industry and other academic institutions.

Most PhD programs do not yield positive financial outcomes from tuition and fees; instead they provide other benefits to the university that make the investment a good one. At MUSC, there is no expectation that the net cost of the Joint PhD program will become positive, but the opportunities it presents to build new research programs, grow MUSC's reputation, and establish new partnerships in the fast-growing field of data science make the investment worthwhile. The negative balance each year consists primarily of faculty salaries and is part of the operating cost of the Biomedical Informatics Center, which is supported by MUSC as a strategic initiative.

### Clemson

<u>Expenses:</u>

Faculty & Staff Salaries

While the program will leverage existing faculty within the interdisciplinary department areas at Clemson, compensation for an assistant professor and part-time support for graduate and administrative coordination has been budgeted. There are no academic administrative costs proposed for the PhD.

Facilities

Support for debt service and facilities.

Other Admin Cost

The category of other administrative costs includes basis support for information technology, student services, and academic services. Marketing to ensure appropriate student quality and demand is included as well.

Revenues:

Tuition Funding

Enrollment is projected to grow incrementally; all doctoral students are expected to be on graduate assistantships and the tuition income is calculated on the basis of the current graduate assistantship rate of $974/semester. Graduate assistantship rates will follow each institutional' s approved and published rates.

Reallocation of Existing Funds

Two Clemson colleges (College of Engineering, Computing and Applied Sciences and College of Behavioral, Social and Health Sciences) will reallocate funds toward the implementation of the joint degree program.

Other Funding

External research support will cover support of graduate stipends and assistantships. It is anticipated that it will take three years to see the growth in grant activity.

## Evaluation and Assessment

**Programmatic Assessment:** Provide an outline of how the proposed program will be evaluated, including any plans to track employment. Identify assessment tools or software used in the evaluation. Explain how assessment data will be used. (3000 characters)

Each academic degree program engages in continuous quality improvement through annual self-assessment of performance on program outcomes (PO) and student learning outcomes (SLO). These data will support continuous quality improvement in the program.

**Program Outcomes**

**PO1: The program performs well on indices of quality**.

Measure 1: The percent of students who complete the program on time (1.5 times expected length=7.5 years).
Target: 90%
Source: Office of Enrollment Management records

Measure 2: Percent of graduating students who obtain full-time employment in a relevant field within one year of graduating.
Target: 90%
Source: Each student's home institution will provide data.

**PO 2: The program performs well on indices of satisfaction**.

Measure 1: Percent of graduating students who agreed that they would recommend the program to other prospective students.
Target: 90%
Source: Graduating student exit survey

Measure 2: Percent of graduating students who agreed that the program met their expectation.
Target: 90%
Source: Graduating student exit survey

**Student Learning Outcomes**

**SLO 1: Students demonstrate sufficient understanding and application of key domains of biomedical data science and informatics (Source: Qualifying Exam rubric)**

Measure 1: Percent of students who sit for the qualifying exam each year that meet or exceed expectations on their responses in the exam that demonstrate an understanding the fundamentals of biomedical data science & informatics concepts.
Target=93% meet or exceed expectations
Source=Relevant row of the rubric for scoring the student's Qualifying Exam

Measure 2: Percent of students who sit for the qualifying exam each year that meet or exceed expectations on their responses in the exam that demonstrate a knowledge of in their track's focus area (i.e., precision medicine informatics, population health informatics or clinical and translational informatics).
Target=93%
Source=Relevant row of the rubric for scoring the student's Qualifying Exam

**SLO 2: Graduating students demonstrate professional skills appropriate for a practicing biomedical data and informatics scientist (Source: Dissertation Defense rubric)**

Measure 1: Percentage of students rated as "meets or exceeds expectations" on the "quality of presentation overall assessment" row of the Oral Defense rubric.
Target=93%
Source=Relevant row of the rubric for scoring the student's Dissertation Defense

Measure 2: Percentage of students rated as "meets or exceeds expectations" on the "cognitive skills overall assessment" row of the Oral Defense rubric.
Target=93%
Source=Relevant row of the rubric for scoring the student's Dissertation Defense

Measure 3: Percentage of students rated as "meets or exceeds expectations" on the "response to questions overall assessment" row of the Oral Defense rubric.
Target=93%
Source=Relevant row of the rubric for scoring the student's Dissertation Defense

Will the proposed program seek program-specific accreditation?

☐Yes

☒No

If yes, provide the institution's plans to seek accreditation, including the expected timeline for accreditation. (500 characters)

Will the proposed program lead to licensure or certification?

☐Yes

☒No

If yes, explain how the program will prepare students for licensure or certification. (500 characters)

**Teacher or School Professional Preparation Programs**

Is the proposed program a teacher or school professional preparation program?

☐Yes

☒No

If yes, complete the following components.

Area of Certification

Please attach a document addressing the South Carolina Department of Education Requirements and SPA or Other National Specialized and/or Professional Association Standards.